Rubber Agroforestry System (RAS) on-farm experimentation in West Kalimantan: Preliminary results of on-farm rice trials in cropping seasons 1994/95, 1995/96 and 1996/97

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Key Words: upland rice, fertilization, *Imperata cylindrica*, pests, herbicide

Introduction

Intercropping with rubber

In West Kalimantan, on the island of Borneo, rubber planting has been integrated into the traditional shifting cultivation cycle for the last 70 years (Dove 1993). The vegetation in the field is slashed, allowed to dry, then burned. This releases a flush of nutrients that are available to the crop of upland rice, which is then planted at the beginning of the rainy season. Rubber trees are also planted at this time and these benefit from the labour invested in weeding the rice crop. Timber, fruit trees and other perennial crops may also be planted.

Effects of previous land use

The type of vegetation which previously covered the plot has an effect on soil structure and fertility and this, in turn, affects the yields of the rice crop. In the case where secondary forest or old jungle rubber was the previous land use type, the soil has a good structure and physical properties due to the deep rooted woody species present and high organic matter content due to litter fall. These effects are built up over the long fallow period. In addition, there is a high biomass of vegetation, which when burned releases a considerable amount of nutrients.

In the case where *Imperata cylindrica* was the previous vegetation, the soil structure is not well developed and soil organic matter content is much lower. The total biomass of vegetation is also considerably lower, which results in lower nutrient additions to the soil when burned. An additional problem is that *Imperata* regenerates quickly after burning and can quickly re-infest the field. This weed competes severely with rubber and if the plot is invaded, rubber growth can be seriously retarded (Wibawa 1997) and there is a high risk of fire. One method of controlling Imperata is tillage, which breaks up the rhizomes in the soil (and as a result, also improves soil physical properties). However this is very labour intensive. Increasingly more popular with farmers is the use of glyphosate herbicide ("Round-Up"), which can be very effective, labour-saving, but also requires a

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capital input. *Imperata* is not shade-tolerant, so when the rubber canopy is developed, it is effectively shaded out.

In *Imperata* dominated areas of West Kalimantan, intercropping rice with rubber provides the farmer with crops from the land during the immature rubber period, and also can prevent weeds from invading the field. Therefore, labour invested in the rice crop in weeding operations also ensures good rubber growth, and the quicker the canopy closes, the quicker the weeds can be overcome.

Upland rice trials

A series of trials was designed to produce recommendations for intercropping rice with rubber in terms of suitable varieties and fertilisation levels. The effect of rice intercropping on rubber growth was also investigated. Results from these trials are presented and discussed in the following sections.

Performance of local varieties of upland rice in Sanggau and Sintang areas

Introduction

In RAS systems, the first year is always cropped with local rice varieties (as improved rice varieties are not yet widely available), except for RAS 2.2 which focuses on trials of both improved and local varieties. A characteristic of farmers of the Dayak ethnic group is the use of certain varieties for making rice wine, which is an important social feature of the Dayak society. Thus, in the future, even if Dayak farmers want to rely on rubber or other income generating activities (a common trend), they will always crop a small area of upland rice with these specific varieties.

Three sets of RAS trials have been established in 1994/95, in 1995/96 and in 1996, and planted with rice after clearing fields with the traditional slash-and-burnpractices. Old jungle rubber was the previous vegetation type in the villages of Kopar, Engkayu, Embaong, whereas Imperata dominated the transmigration villages of Trimulia and Pariban Baru. Soils are poor, heavily leached, red/yellow ferralitic, with low CEC.

Characteristics of the trial locations are summarized below. Rice yields are presented in Table 1 (for 1994/95), Table 2 (1995/96) and Table 3 (191996 in Embaong and Kopar) with graphs.

Characteristics of trial locations

Location	Characteristics	Observations
KOPAR Trial 1	Traditional secondary forest environment with high occurrence of *Imperata*. RAS 1, 2 and 3.	Very poor sandy soils. Young secondary forest with very poor vegetation. Recent development of oil palm on this type of land. Dayak people.
ENGKAYU Trial 1	Traditional secondary forest environment with medium to high occurrence of *Imperata*. RAS 1, 2 and 3.	Poor soils. Forest/old jungle rubber environment. Priority given to rubber cropping systems. Dayak people.
EMBAONG Rice in RAS 1 first year only	Traditional secondary forest environment with medium occurrence of *Imperata*. RAS 1.	SRDP[1] since 1987 (clonal rubber monoculture) with very old jungle rubber converted into RAS. Forest environment. Dayak people.
TRIMULIA Trial 3	Transmigration area (formerly for foodcrops). Local strategy: priority to irrigated rice cultivation. RAS 2 and 3.	*Imperata* grasslands. Extensive upland cropping system. Javanese people.
PARIBAN BARU/ SINTANG Trial 2	Transmigration area (formerly for foodcrops). *Imperata* savannah. Local strategy: priority given to improved rubber. RAS 2.	*Imperata* grasslands. Extensive upland cropping system. Javanese people.

Performance of local rice varieties

Cropping season 1994/1995:Table 1 and Figure 1

Local rice varieties have an average yield of around 600 kg/ha in a range of 250 to 1250 kg/ha (445 kg/ha for Kopar, 702 kg/ha for Engkayu). Rice was cultivated after slash-and-burn of old jungle rubber, with chemical fertilization, and sometimes in *Imperata* infested land (Pariban Baru). Most of these local varieties may be used for rice wine production.

The lower yields were due to depredation by insects and birds, a low planting density and generally low weeding level, with high occurrence of *Imperata.*

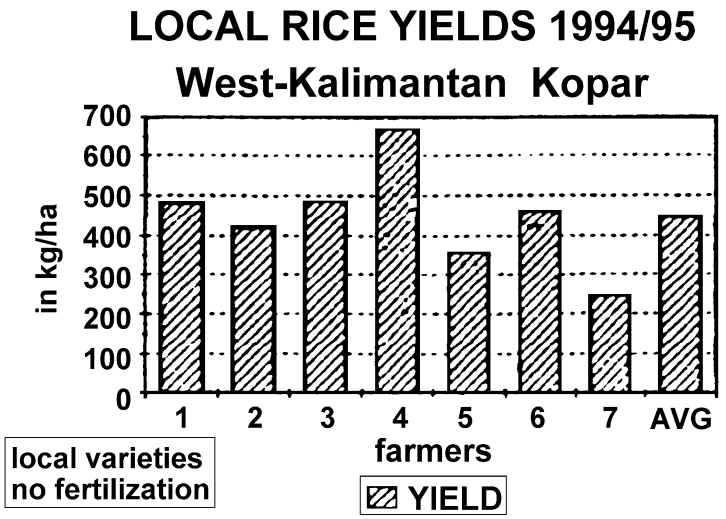
[1] SRDP: Smallholder Rubber Development Project

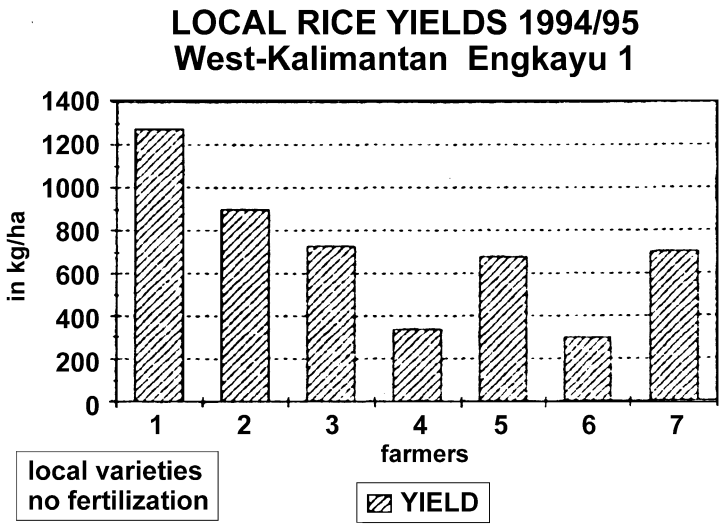
Table 1. **Upland rice yield observed in RAS plot local varieties first planting after slash-and-burn, West Kalimantan**

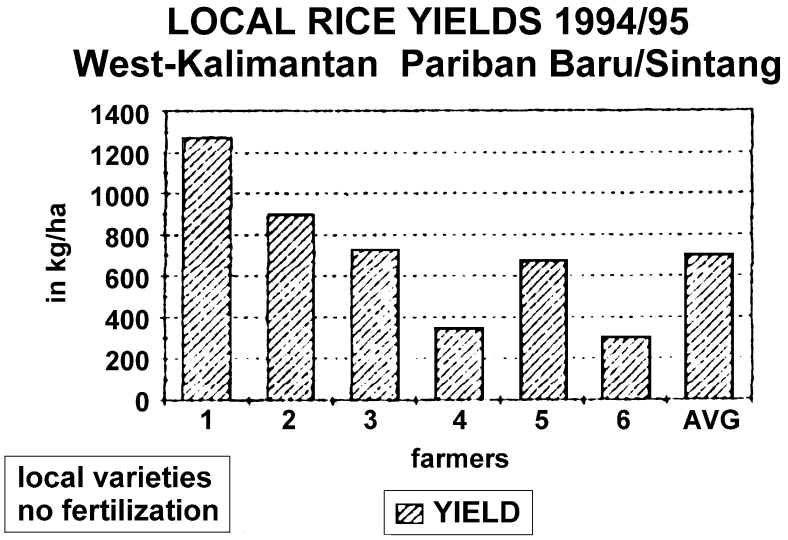
Village	Farmer	Variety 1994/1995	Cycle in month	Yield in kg/ha
Kopar	Sudin	mix up	6	479
local varieties for rice wine	Indi	mix up	6	418
no fertilization	Muksin	pulut	6	486
	Stepanus	pulut	6	668
	Abui	nunggu	6	360
	Kai	pulut	6	460
	Jampi	pulut	6	246
Average			**AVG**	**445**
Standard			**STD**	**120**
CV			**CV**	**27%**
Engkayu I	Francisco	banjar kuning	6	
local varieties for rice wine	Gabriel 1	pulut	6	1,274
no fertilization	Gabriel 2	mix up	6	897
	Bakun	mamu	6	729
	Christianus	mix up	6	340
	Andreas	pulut	6	674
	Gamin	nunggu	6	299
Average			**AVG**	**702**
Standard			**STD**	**332**
CV			**CV**	**47%**
Pariban Baru	Sadang	Klanggau	4	1,029
Sintang	Sudin	Klanggau	4	714
Local variety for consumption	Anat	Klanggau	4	533
	Sanggang	Klanggau	4	625
Transmigration area	Amas	Klanggau	4	878
	Haruk	Klanggau	4	725
Sheet Imperata Cylindrica	Atat	Klanggau	4	580
Savannah	Apin	Klanggau	4	403
No fertilization				**686**
Average			**AVG**	**185**
Standard			**STD**	**27%**
CV			**CV**	

Village	Farmer	Variety 1995/1996	Cycle	Yield
Trimulia				
Transmigration area	Pryo Aryono	Embatu	4	29
Sheet Imperata Cyl-indrica	Poniman	Embatu	4	117
	Yasdi	Embatu	4	150
Savannah	Sodianto	Embatu	4	39
All plots with BPS fertilization dosis				
Average			**AVG**	**84**
Standard			**STD**	**51**
CV			**CV**	**61%**

Figure 1. **Comparison of Local Rice Yields**







Source: SRAP/GAPKINDO/ICRAF 1996

Cropping season 1995/1996:Table 2 and Figure 2

Local rice gave an average yield of around 500/600 kg/ha after slash-and-burnof old jungle rubber (for Kopar and Engkayu) without any chemical fertilization. Most of these local varieties may be used for rice wine production. Yields range from 160 to 800 kg/ha. Yields in *Imperata* infested land (village of Trimulia) are very low, between 29 and 150 kg/ha, due to poor management and infestation with *Imperata*. Lack of weeding and severe competition from *Imperata* almost led to crop failure despite the plots receiving fertilization (BPS[2] recommendations).

In Engkayu, the average yield of rice with BPS level fertilization (451 kg/ha) is inferior to that without fertilization (521 kg/ha) in the same type of environment (after slash-and-burn of old jungle rubber). One explanation might be that these local varieties (especially those for rice wine) may not respond well to fertilization. Another explanation may be that without insect pest control, yields are dramatically affected by rice planthopper ('walang sangit') and lead to severe crop losses.

[2] BPS: Sembawa Research Station

***Table* 2. Upland rice yield observed in RAS plot in the 1995/96 planting season, West Kalimantan**

Village	Farmer	Type of RAS	No. of years of planting after S & B	Variety 1994/1995	Area in m^2	Fertili-zation	Cycle in month days	Yield in kg/ha
Engkayu I	Gabriel/1	RAS/3 clones control	2	Pulut Semanu	5,000	no	179	615
Engkayu I	close to Otol	Vegetables	1	Pulut Bagus	9,000	no	170	657
Kopar	Close to Indi	Young jungle rubber	1	Semanu Serunglup	1 ha	no	170	420
Trimulia	Pryo Aryono	2.1	1	Way Rarem	5,000	BPS	164	29
Trimulia	Poniman	2.1	1	Way Rarem		BPS	172	117
Trimulia	Yasdi	2.1	1	Way Rarem		BPS	161	150
Trimulia	Sodianto	2.1	1	Way Rarem		BPS	147	29
Engkayu II	LC Lahong	1.1/DP550	1	Rupo		no	152	462
Engkayu II	Sik	1.1/DP550	1	Demam Pulut		no	167	274
Engkayu II	Tinus	1.1/DP550	1	Bagus Nyerungcup		no	167	754
Engkayu II	Goling	1.1/DP750	1	Terjak		no	173	814
Engkayu II	Otol	1.1/DP750	1	Bagus Pulut		no	169	656
Engkayu II	Apan	1.1/DP750	1	Pulut		no	155	163
Engkayu II	Angkong	3.3/orok[2]	1	Nyerungcup		BPS	162	492
Engkayu II	Noh	3.3/orok[2]	1	Pulut		BPS	169	332
Engkayu II	Bansa	3.3/flemingia	1	Pulut Nyerungcup		BPS	188	293
Engkayu II	Joni	3.3/flemingia	1	Pulut Nyerungcup		BPS	165	688

Cropping season 1996/1997:Table 3 and Figure 3

Rice yields in Embaong for local varieties are quite high with an average of 1182 kg/ha (although there was a wide variation in yield ranging from 154 to 2493 kg/ha). This is probably due to three factors:

- soils were rich in nutrients after the burning of 45-year old jungle rubber,
- crops have been protected against insect pests during the last month before harvest (in particular against walang sangit), and
- crops have been fertilized with BPS doses.

It seems that the combination of fertilization + crop protection pays off.

***Table* 3. Upland rice yield observed in RAS plot local varieties first planting after S&B, West Kalimantan**

		Variety 1996/97	Cycle in month	Yield in kg/ha
EMBAONG	DANCO	Kuning	6	1,642
Old jungle rubber more than 45 years old	SAMI	Yon	6	481
	LATIN	embatu	4	869
All plots with BPS	LOHENG	meliau	6	1,725
Fertilization dosis	SIDON	Yon/pulut*	6	2493
	TONIL	Putih/pulut*	6	154
	CACOT	kumpang	6	690
	ALOSIUS	embatu	4	2,053
	LIDI	wi + pulut	6	532
		AVG		**1,182**
		ATD		**767**
KOPAR	INDI II	mamut	6	1.185
young secondary forest on poor sandy soils		pulut	6	499
	STEPANUS II	mamu	6	1.129
	KOLANUS	mamu	6	17102
		embatu	4	988
	YOHANES	pulut	6	285
		jengkot	6	1,314 1
		embatu	4	1.566
	AKUT	semamu	6	1.413
		serungkup	6	1,693
		embatu	4	2,608
			AVG	**1,344**
			STD	**500**
			CV	**37%**

In Kopar, where new plots have been established from relatively young secondary forest *('belukar'*), rice yields are exceptionally high; an average of 1344 kg/ha (and a range of 449-2608 kg/ha). This is remarkable when compared to yields observed in 1994/95 (average yield of 445 kg/ha) on the same type of poor soils and poorly developed secondary vegetation (young belukar). Crop protection and fertilization (BPS dose) with good weeding (due to good farmer motivation) may explain such results.

However, the differences between years may also be partly due to bias in sampling. In 1994/95 and 1995/96, rice production was measured over the whole field, but in 1996/97 samples of 10 m^2 were used due to labour shortage.

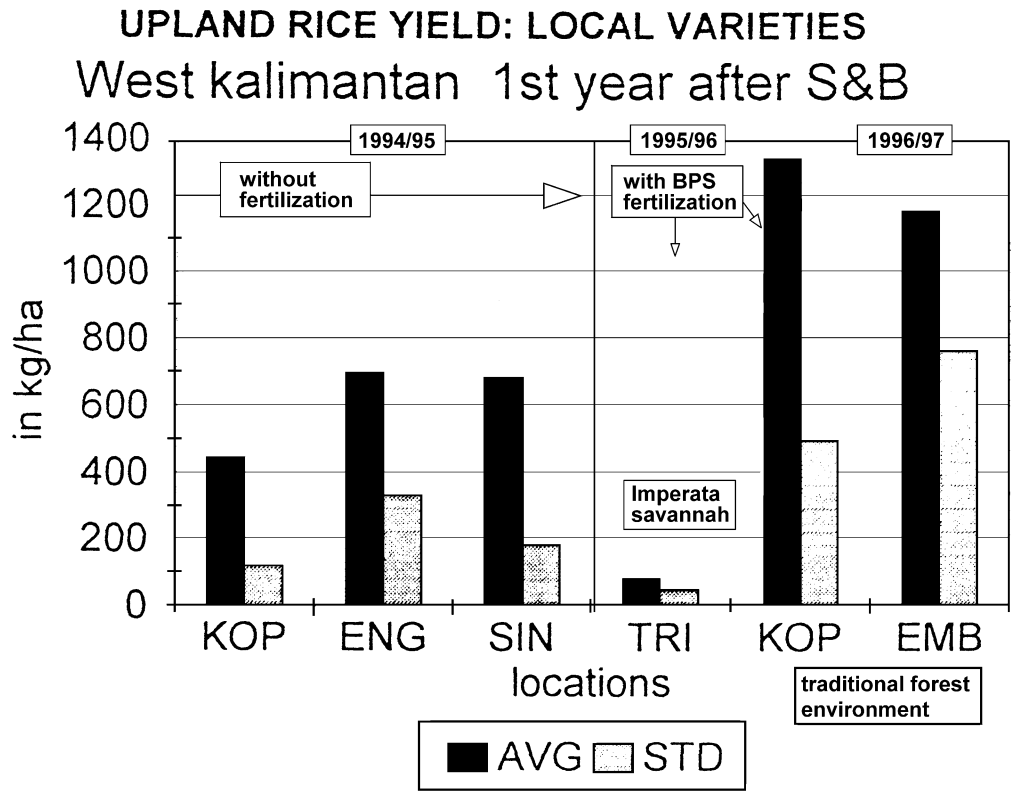
Conclusions

Some local varieties have very good potential. However, some, particularly those selected for rice wine production, may have a relatively limited production potential if crop protection and fertilization are not carried out. Fertilization linked with crop protection (against insects and birds), and two weedings, as implemented in 1996/97, have almost tripled yields from an average 445 kg/ha in 1994/5 to 1344 kg/ha in 1996/97 (Table 4).

Table 4. **Upland rice yield observed in RAS plot local varieties first planting after slash-and-burn, West Kalimantan**

Location	Precedent	Age in years	Yield in AVG	STD	CV	Code
Kopar	Belukar	7/12	445	120	27%	KOP
Engkayu	jungle rubber	10/20	702	332	47%	ENG
Sintang/ Pariban Baru	Imperata		686	185	27%	SIN
Trimulia	Imperata	15	84	51	61%	TRI
Kopar	Imperata/belukar	0.5	1,344	500	37%	KOP
Embaong	jungle rubber	45	1,182	767	65%	EMB

Figure 4.



Reasons for some of the low yields observed are as follows:

- low planting density due to traditional way of rice cropping,
- late planting in 1995 due to delay in field preparation: too much rain in the dry season and burning was delayed,
- damage by rice bugs and other insects,
- low initial soil fertility,
- loss of ash in surface water run-off, due to heavy rains after burning.

RAS 2.2 Rice trials in the first year of planting

The types of OFT (On-Farm Trials) are explained below.

- Trial 1
  Four replications in two Dayak villages in Sanggau area: Kopar and Engkayu.
  The first year of rubber and rice planting was 1995.
  A high density of associated trees (275 trees/ha) was also planted.
- Trial 2
  Nine replications in Pariban Baru and Sintang (transmigration area).
  Third year after rubber planting.
  Rice trials were implemented in cropping seasons 1995/96 and 1996/1997, as follows:

Four replications with a ‘high’ density of associated trees (275 trees/ha)
Five replications with a ‘medium’ density of associated trees (135 trees/ha)

- Trial 3
  Four replications in Trimulia, a Javanese transmigration village
  A ‘low’ density of associated trees (92/ha).

In addition to these experiments, farmers in Embaong village wanted to grow improved rice varieties in their RAS 1 plots, to compare yields with their local rice varieties. Fields were divided into "improved rice" and "local rice", with the same BPS fertilization and crop protection. Results are presented in Table 9.

Implementation

Trial 1: Rubber planted between December 1994 and February 1995.

RAS 2.2 with rice experiment in the first year

Trial 2: Rubber planted in December 1993.

RAS 2.2 with rice experiment in the third year (the first year of rice was before rubber planting)

Trial 3: Rubber planted: January-February 1996.

RAS 2.2 with rice experiment in the first year

Treatments

Year 1

Treatment 1: 3 rice varieties

local - "Embatu" or "Klanggau"

improved - "Way Rarem"

improved - "Danau Tempe" (or "Jatiluhur")

Treatment 2: 3 levels of fertilisation

No fertiliser

1/2 BPS recommended dose

Full BPS recommended dose

(BPS dose/ha is: 100 kg urea, 140 kg SP 36 and 75 kg KCL)

Number of plots : 9 per replication (each farm is considered a replication)

Experimental design : Split-plot, with main treatment on rice variety and sub-treatment on fertilization.

NB. No pesticide was used to protect crop from pests and insects.

ANOVA has not been carried out due to high variability of results.

Year 2

In Year 2, the experimental design was changed, as experience from Year 1 showed that the original nine plots per farm was too much for farmers to manage (except for those in Pariban Baru). Therefore, the number of plots was reduced to four per farm, by removing the rice variety treatment. Thus each farmer compared three levels of fertilization on one variety only. The simplification of the trial design enabled the farmers to manage the experimental fields satisfactorily.

Fertilization treatment : 1 plot with the selected variety: 0 fertilization

1 plot with the same variety, BPS recommended fertilization

1 plot with the same variety, CRIFC recommended fertilization (150 kg urea, 220 kg SP-36, 150 kg KCl)

(A fourth plot was included, with the local rice variety for wine production, as this was requested by the farmers. However, yields from this plot were not included in the analysis of the experiment.)

Main results of the first trials (1995/1996)

Trial 1 In Kopar & Engkayu and Trial 2 In Pariban Baru

Cassava is grown as an associated food crop with rice in all fields in Kopar & Engkayu. Rice does not cover the soil well as the planting density is generally too low. The effect of fertilization is clear; the differences are significant between the no fertilizer treatment and the full BPS dose. However, yields are low, particularly in Pariban Baru, where the rice is intercropped with 3.5-year-old rubber. In this case, the effect of shading may be important as the PB 260 clonal rubber trees grow very fast.

Generally, yields of Way Rarem and Embatu do not recoup the cost of fertilization. In Kopar and Engkayu, BPS fertilization raised yields of Embatu from 480 to 740 kg/ha. The fertilizer response was greater than that of Way Rarem, which suffered from blast (fungal disease) and depredation by insects and birds (Table 5, 6 and 7). Therefore, in these conditions, the risk of investing in fertilization, particularly with "improved varieties" such as Way Rarem, Danau tempe or Jatiluhur, is not justified if there is no crop protection. The effect of fertilization on local varieties (Serunglup and Pilih) was comparable to that for Embatu (Table 5).

Table 5. **Upland rice yield observed in RAS plot 1995/96 planting season, West Kalimantan**

RAS 2.2 Rice Variety x Fertilization Experiment

Year after S&B	Village Dusun	Farmer	Rep nb	T1 rice variety	T2 dose	Date of planting date in 1996	Date of harvest	Cycle in days	Yield per plot 400 m2	Yield per ha adjusted 14%	Index/ dose = 0
2	Kopar I	Muksin	1						NOT HARVESTED		
2	Engkayu	Gabriel/2	2	Way Rarem	1/1	30/10	12/2/96	104	6.8	263	2.3
				Way Rarem	1/2		13/2/96	105	3.9	181	1.6
				Way Rarem	0		14/2/96	106	2.5	113,	
				Embatu	1/1	12/10		late plan	0.0	0	
				Embatu	112				0.0	0	
				Embatu	0				0.0	0	
				Way Rarem	1/1	30/10	12/2/96		3.4	762	
				Way Rarem	1/2			104 alang[2]	0.0		
				Way Rarem	0				0.0		
								alang[2]	0.0		
2	Engkayu	Andreas	3	Way Rarem	1/1	29110	3/2/96	97	8.8	505	1.8
				Way Rarem	1/2		14/2/96	108	6.9	329	1.2
				Way Rarem	0		19/2/96	113	5.9	282	
				Embatu	1/1	13/10	12/2/96	121	19.0	1,095	1.4
				Embatu	1/2		1612/96	125	16.3	780	1.0
				Embatu	0		19/2/96	129	15.8	760	
				Way Rarem	1/1	29/10	11/2/96	105	6	333	1.4
				Way Rarem	1/2		11/2/96	105	4	236	1.0
				Way Rarem	0		19/2/96	113	2	230	
2	Engkayu	Gamin	4	Way Rarem	1/1	28/10	7/2/96	102	4.5	207	ERR
				Way Rarem	1/2		7/2/96	102	1.5	69	ERR
				Way Rarem	0						
				Embatu	1/1	28/10	1812/96	113	8.5	391	1.9
				Embatu	1/2		20/2/96	115	5	230	1.1
				Embatu	0		20/2/96	115	4.5	207	
				1 serie destroyed by birds							

Average rice cyle in days
Way Rarem 105
Embatu 119

Figure 5.

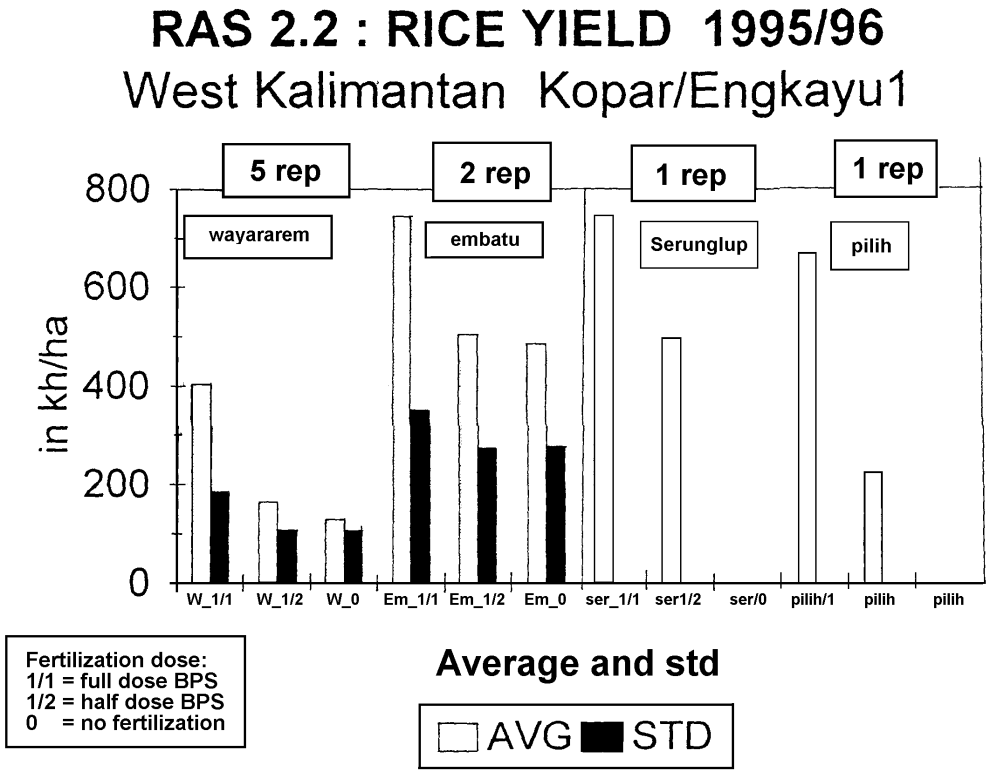


Table 6. **RAS 2.2 Rice Variety x Fertilization Experiment, West Kalimantan 1995/96**

			Average all plots			
Nb of r rep	Variety	Level	AVG kg/ha	STD kg/ha	CV %	Index/level 0
	Improved Variety					
5	Way Rarem	1/1	404	185	46%	3.1
5	Way Rarem	1/2	164	107	65%	1.3
4	Way Rarem	0	129	106	83%	
	Local Variety					
2	embatu	1/1	743	352	47%	1.5
2	embatu	1/2	505	275	54%	1.0
2	embatu	0	483	276	57%	
1	serunglup	1/1	747	0	0	1.5
1	serunglup	1/2	498	0	0	
1	serunglup	0	0	0	0	
1	pilih	1/1	666	0	0	3.0
1	pilih	1/2	222	0	0	
1	pilih	0	0	0	0	

Figure 6.

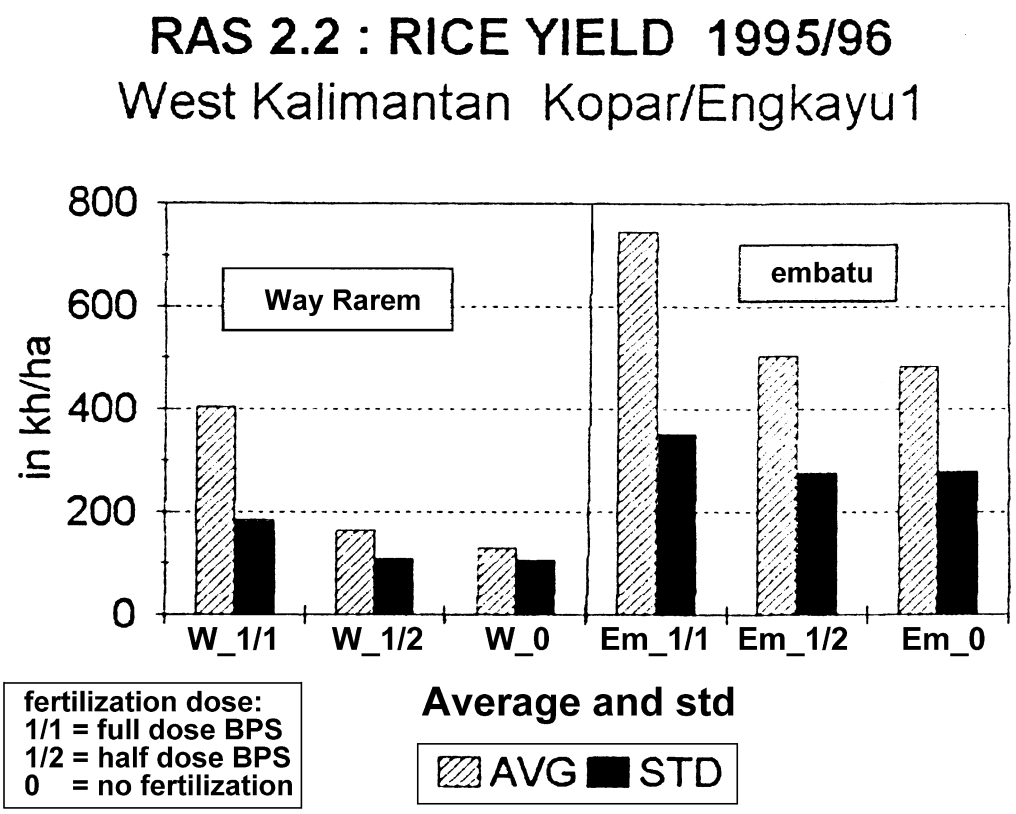


Table 7. **Upland rice yield observed in RAS plot in the 1995/96 planting season, West Kalimantan**

Ras 2.2 rice variety x fertilization experiment

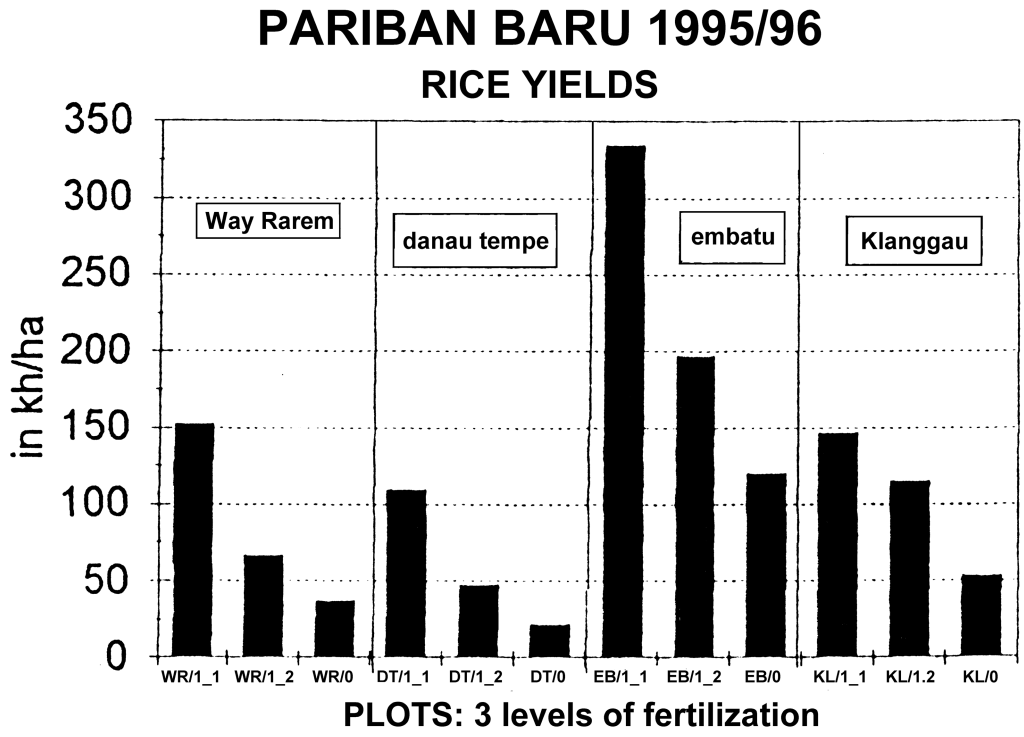
Average Yield and Index Per Variety

Pariban Baru/Sintang: 9 rep

Number of rep	Rice Variety	Dosis fertilizers	Kg/ha average	Index/dosis=0	Index/KL klanggau
9	WR	1/1	195	5.21	1.33
9	WR	½	67	1.78	0.58
8	WR	0	38		0.71
9	DT	1/1	122	5.68	0.83
9	DT	½	48	2.23	0.41
9	DT	0	22		0.41
4	EB	1/1	335	2.79	2.28
4	EB	1/2	198	1.65	1.71
		0	120		2.26
4	KL	1/1	147	2.76	
4	KL	1/2	116	2.18	
4	KL	0	53		

Klanggau is the local upland rice

Figure 7.



In Pariban Baru, the local variety (Klanggau) has lower yields than Embatu. Embatu is a local variety from the village of Sungei Kossak, located in the Sanggau area, identified by Ir Sunario for experimentation in RAS. This variety has proved to be very well adapted to local conditions and has a cycle of four months. Yields are extremely low (from 150 to 300 kg/ha with BPS fertilization) and do not justify the cost of fertilization in spite of the great effort the farmers put into their rice fields. The best yields have been recorded in some plots on selected area of 50 m^2 in order to have an idea of the real potential of production with BPS fertilization (Figure 8). Yields range from 938 to 1875 kg/ha.

Figure 8.

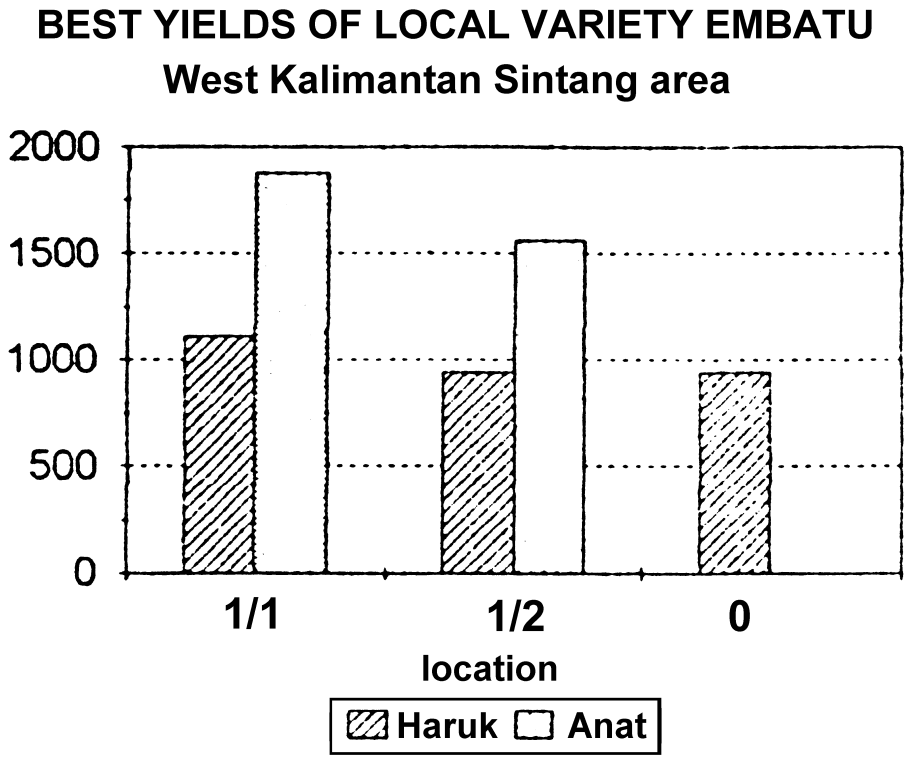


Table 8. **Rice Yields in Selected Plot of 50 m^2**

Rice Variety	Fertilization Level	Location Haruk	Anat
EB	1/1	1111	1875
EB	1/2	938	1563
ES Embatu	0	938	

Upland rice yield observed in RAS plot 1995/96 planting season, West Kalimantan

RAS 2.2 Rice Variety x Fertilization Experiment
Village of Pariban Baru Sintang Area Transmigration
Age of Rubber Trees: 3.5 years (planting in Dec 1993)

Farmer	Rep nb	T1 rice variety	T2 dose	planting date in 1996	Date of harvesting	Cycle in days	Yield per plot 1400 m^2	Yield per ha	Index/dosis=0	Note	observations
ASSOCIATED TREES: medium density (140 trees/ha)											
Sudin	1	Variety	Dosis		February						
		WR	1/1	25/10	10	102	4.5	113	2.25	5	very good growth
		WR	1/2		9	101	4	100	2.00	4	growth correct, heterogeneous
		WR	0		7	99	2	50		3	growth correct
		DT	1/1	25/10	16	108	2	50	2.00	0	very poor growth, bad quality seeds
		DT	1/2		16	108	1	25	1.00	1	very poor growth, weedy
		DT	0		16	108	1	25		0	very poor growth
		EB	1/1	28/9	15	140	15	375	1.88	5	very good growth
		EB	1/2		17	142	12.5	313	1.56	4	very good growth
		EB	0		17	142	8	200		5	very good growth

Farmer	Rep nb	T1 rice variety	T2 dose	planting date in 1996	Date of harvesting	Cycle in days	Yield per plot 1400 m^2	Yield per ha	Index/dosis=0	Note	observations
ASSOCIATED TREES: medium density (140 trees/ha)											
Haruk	2	WR	1/1	25/10	20	119	7	175	7.001	4	good growth
		WR	1/2		21	120	2.5	63	2.50	1	poor growth, weedy
		WR	0		21	120	1	25		3	growth correct
		DT	1/1	25/10	26	93	5.5	138	5.50	1	poor growth
		DT	1/2		28	95	1	25	1.00	1	very poor growth, weedy
		DT	0		28	95	1	25		0	very poor growth weedy
		EB	1/1	30/9	23	137	17.5	438	4.38	5	very good growth
		EB	1/2		24	138	9.5	238	2.38	1	very heterogeneous. weedy
		EB	0		22	136	4	100		1	late planting
Sadang	3	WR	1/1	25/10	9/2	108	10	416	555	5	lack of N. yellowish
		WR	1/2		2/3	128	3	75		1	poor growth. weedy
		WR	0					zero		1	very poor growth
		DT	1/1	25/10	9/3	136	7.5	188		0	bad quality seeds: no growth
		DT	1/2		-			0		1	poor growth, weedy
		DT	0					0		2	very poor growth
		EB	1/1	25/9	5/3	161	12.5	313	4.17	3	growth correct, weedy
		EB	1/2		12/2	140	5.5	138	1.83	5	
		EB	0		7/3	163	3	75		5	good growth. heteronegenous

Farmer	Rep nb	T1 rice variety	T2 dose	planting date in 1996	Date of harvesting	Cycle in days	Yield per plot 1400 m^2	Yield per ha	Index/dosis=0	Note	observations
ASSOCIATED TREES: medium density (140 trees/ha)											
Anat	4	WR	1/1	26/10	152	112	9.5	238	2.11	1	heterogeneous
		WR	1/2		-			zero	0.00	0	very poor growth
		WR	0		17/2	114	4.5	113		2	heterogeneous
		DT	1/1	26/10	2/3	125	7.5	300	12.00	3	very heterogeneous
		DT	1/2		4.3	127	2	50	2.00	0	very poor growth
		DT	0		15/1	94	1	25		0	heterogeneous
		EB	1/1	29/9	8/3	162	22	550	2.44	5	very good growth
		EB	1/2		19.2	145	12	300	1.33	5	very good growth
		EB	0		19.2	145	9	225		5	very good growth
Amas	5	WR	1/1	25/10	7/2	105	5	208	2.77	2	poor growth. heterogeneous, weedy
		WR	1/2		8/2	106	3	75		1	very poor growth
		WR	0					0		1	heterogeneous
		DT	1/1	25/10	2/3	128	8	200	2.46	1	very poor growth
		DT	1/2		5/3	131	6.75	169	2.08	1	very poor growth
		DT	0		6/3	132	3.25	81		1	very poor growth
		EB	1/1	2/10	-						cancelled
		EB	1/2		-						
		EB	0		-						

Farmer	Rep nb	T1 rice variety	T2 dose	planting date in 1996	Date of harvesting	Cycle in days	Yield per plot 1400 m^2	Yield per ha	Index/dosis=0	Note	observations
ASSOCIATED TREES: high density (275 trees/ha)											
Apin	1	WR	1/1	25/10	20/2	123	3.5	88	2.33	1	poor tiler, poor growth; weedy
		WR	1/2		20/2	123	1.5	38		1	very poor growth
		WR	0					0		0	very poor growth
		DT	1/1	25/10	-			0		0	no growth
		DT	1/2		18/2	121	2	50		0	very poor growth
		DT	0					0		0	no growth
		KL	1/1	7/10	18/2	139	4.5	113	0.82	3	growth correct, heterogeneous, weedy
		KL	1/2		18/2	139	5.5	138		3	poor tiler
		KL	0		-			0		1	poor growth
Hukir	2	WR	1/1	25/10	12/2	100	4.5	113	4.50	5	very good growth
		WR	1/2		12/2	100	2.5	63	2.50	1	poor growth. weedy, heterogeneous
		WR	0		12/2	100	1	25		1	growth correct
		DT	1/1	25/10	17/2	105	2	50	4.00	1	very poor growth, weedy
		DT	1/2		17/2	105	2.5	63	5.00	0	very poor growth
		DT	0		17/2	105	0.5	13		0	no growth
		KL	1/1	10/10	3/3	124	8.5	213	1.89	4	very poor growth. weedy
		KL	1/2		1/3	122	7	175	1.56	3	heterogeneous, growth correct
		KL	0		1/3	122	4.5	113		1	very poor growth

Farmer	Rep nb	T1 rice variety	T2 dose	planting date in 1996	Date of harvesting	Cycle in days	Yield per plot 1400 m^2	Yield per ha	Index/dosis=0	Note	observations
ASSOCIATED TREES: high density (275 trees/ha)											
Sanggang	I	WR	1/1	25/10	10/2	98	8	333	2.66	5	good growth, weedy
		WR	1/2		6/2	94	5.5	138	1.10	2	yellowish, weedy
		WR	0		12/2	100	5	125		5	growth correct
		DT	1/1	25/10	20/2	108	5	125	2.50	3	poot tiler, heterogeneous. weedy
		DT	1/2		20/2	108	2	50		2	poot tiler. heterogeneous, weedy
		DT	0					0		0	very poor growth
		KL	1/1	29/9	2/3	155	6.5	163	3.25	5	good growth
		KL	½		2/3	155	4	100	2.00	3	growth correct
		KL	0		1/3	154	2	50		1	very poor growth, lack of N
Ata	4	WR	1/1	25/10	15/2	103	3	75	1.50	2	very heterogeneous
		WR	1/2		15/2	103	2	50		0	very poor growth
		WR	0								cancelled
		DT	1/1	25/10	20/2	108	2	50	2.00	1	weedy, very poor growth
		DT	½		-			0	0.00	0	very poor growth
		DT	0		20/2	108	1	25		0	very poor growth
		KL	1/1	9/10	15/2	108	4	100	2.00	4	growth correct, heterogeneous
		KL	½		18/2	111	2	50	1.00	4	growth correct, heterogeneous
		KL	0		18/2	111	2	50		3	growth correct, heterogeneous

Note on farmers fields:

Sudin	Rubber growth is very slow, few shading	Hukir	plot with very low rubber growth, Few shading
Haruk	plots are very heterogeneous	Sanggang	plot with very low rubber growth, Few shading
Amas	strong effect of shading of rubber trees	Ata	strong effect of shading of rubber trees

Average rice cycle in days:

Way Rarem	108
Danau Tempe	112
Embatu	146
Klanggau	130

The level of weeding was generally not enough to overcome the threat of *Imperata*. One weeding, sometimes two, is implemented. The first rice crop was generally well weeded, but *Imperata* and other weeds usually invaded the plot in the second year. Damage by rice bugs after flowering and depredation by birds led to poor yields.

Growth and biomass production was generally good for the local varieties, but very variable for Way Rarem, and very poor for Danau Tempe (particularly in Pariban Baru) due to poor seed quality and the subsequent low germination).

Trial 3 in Trimulia

Rice experimentation in RAS 2.2 in Trimulia village was a total failure as farmers showed little interest in upland crops and *Round-up* was used incorrectly. This led to a very rapid infestation of *Imperata* over the whole field. Obviously, farmers give priority to irrigated rice ('sawah'), and to off-farm activities. Farmers consider that upland cropping, rice in particular, to be very risky in that area due to both *Imperata* and the other weeds that come in after *Imperata* has been suppressed. These can cover the fields very rapidly (in less than one month) and compete severely with rice. Local knowledge suggests that the only way to get rid of *Imperata* and control these other weeds efficiently is to till the fields (if possible with draught power), and then grow groundnut with two or three weedings per crop. However, returns to labour seem to be too low for this to be feasible, especially under current conditions where tillage is done manually. This explains the farmers' interest in better paid off-farm activities.

Conclusion

A constraints analysis is necessary to identify the constraints other than soil fertility. These constraints are:

- severe competition from weeds (e.g., *Imperata*), especially in transmigration areas with sheet *Imperata*,
- low planting density and traditional cropping methods,
- effect of pests and disease (rice bugs and blast),
- erratic rainfall (water deficit or damages by heavy rains),
- light competition from rubber tree canopies three years after planting,
- seed quality of improved varieties,
- soil compaction after three years of no tillage; a rotation of rice and groundnuts (with tillage for the second crop) seems to be necessary.

Improved rice varieties with BPS* fertilization and crop protection on RAS 1 and RAS 3 plots in Embaong and Kopar villages, 1996/97

The previous trials in 1994/95 and 1995/96 showed that without fertilization and crop protection, improved varieties were not suitable and gave lower production

than local varieties, in particular Embatu. In the first year of RAS 1 and RAS 3 establishment, farmers in the villages of Embaong and Kopar wanted to grow both local and improved rice in the same fields with BPS fertilization and crop protection in order to compare yields. Results are presented in Table 9. BPS fertilization level is that recommended by the Rubber Research Station of Sembawa, IRRI, in South Sumatra.

Figure 9

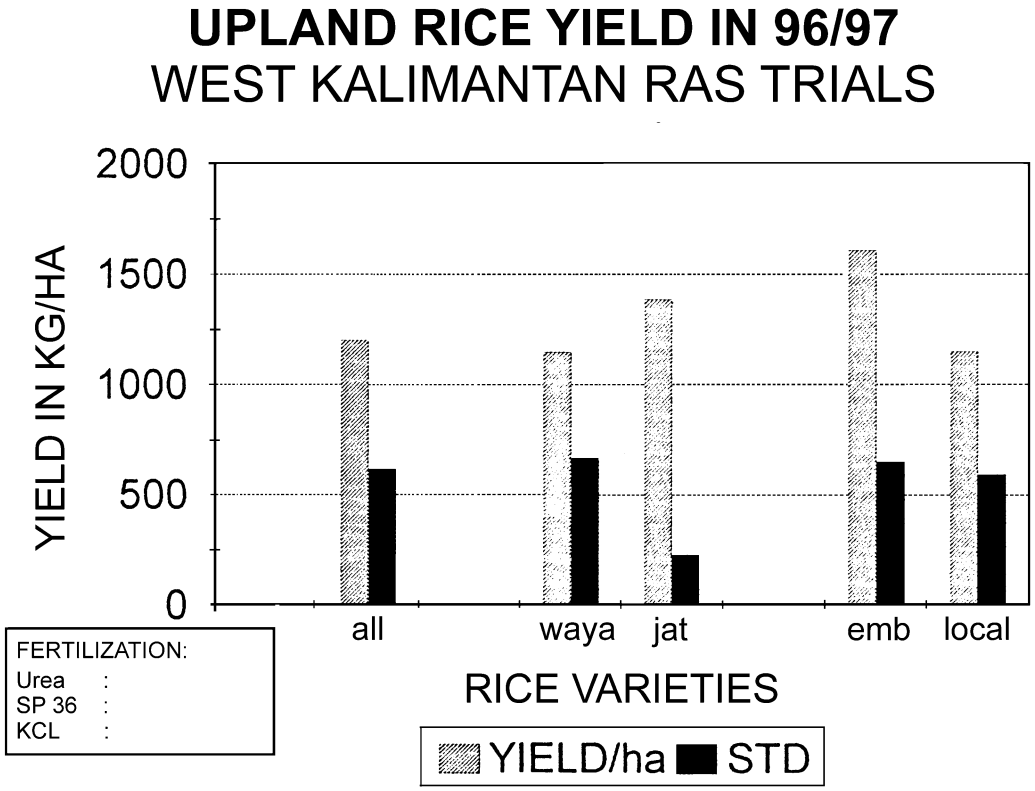


Table 9. **Upland rice yield observed in RAS plot in the 1996/97 planting season, West Kalimantan**

Variety		Yield/ha	STD	CV	Nb plots	Index/local variety
Total average all plots first year	all	1,202	617	51%	26	104%
IMPROVED VARIETIES		1,149	666	58%	3	99%
Average Way Rarem	waya	1,391	228	16%	3	120%
Average jatiluhur	jat					
LOCAL VARIETIES		1,617	653	40%	5	140%
Average Embatu	emb	1,156	591	51%	15	
Average other local varieties	local					

Village Dusun	Farmer	Type of RAS	Rice planting in 96/97					GROSS Yield	% dry	Net Yield	Intercropped
			Planting	Harvesting	Variety		Fertilizers Number of weedings				
Embaong	DANCO	RAS 1.1	4/10	22/1	Jatiluhur	1	BPS	1975	0.254	1,713	
			2618	20/2	Kuning			1893	0.254	1,642	
	SAMI	RAS 1.1	24/9	28/2	Yon	1	BPS	481		481	
	LATIN	RAS 1.1	20/9	1/3	Embatu	1	BPS	869		869	
	LOHENG	RAS 1.1	1/10	22/1	Jatiluhur	1	BPS	1425	0.245	1,251	
			24/8	26/2	meliau	1	BPS	1965	0.245	1,725	
	SIDON	RAS 1.1	28/8	10/2	Yon/pulut	1	BPS	2493		2493	
	TONIL	RAS 1.1	23/8	8/2	Putih/pulut	1	BPS	154		154	
		Clone Comparison									
Embaong	JAMPI	RAS 1.2									
	CACOT	RAS 1.2	24/9	28/2	Way Rarem	1	BPS	750	0.251	653	
			5/9	6/3	kumpang	1	BPS	690		690	
	ALOSIUS	RAS 1.2	18/9	25/2	embatu	1	BPS	2125	0.169	2,053	
	LIDI	RAS 1.2	24/9	28/2	jatiluhur	1	BPS	1275	0.184	1,210	
			28/8	28/2	wi + pulut	1	BPS	532		532	

Village Dusun	Farmer	Type of RAS	Rice planting in 96/97					GROSS Yield	% dry	Net Yield	Intercropped
			Planting	Harvesting	Variety		Fertilizers Number of weedings				
Kopar	INDI 11	3.2	25/9	31/1	Way Rarem	1	BPS	725	0.164	705	
			2819	7/2	mamut	1	BPS	1300	0.216	1,185	
			28/9	7/2	Pulut	1	BPS	525	0.182	499	
	STEPANUS II	3.2	25/9	29/1	Way Rarem	1	BPS	300	0.163	292	
			14/9	17/2	mamu	1	BPS	1250	0.223	1,129	
	KOLANUS	3.2	7/9	17/2	mamu	1	BPS	1150	0.176	1.102	
			24/9	17/2	embatu	1	BPS	1050	0.191	988	
	YOHANES	3.2	8/9	18/2	Pulut	1	BPS	1325	0.166	1,285	
			8/9	18/2	jengkot	1	BPS	1350	0.163	1,314	
			24/9	18/2	embatu	1	BPS	1640	0.179	1,566	
	AKUT	3.2	4/9	20/1	semamu	1	BPS	1560	0.221	1,413	
			23/8	2011	serungkup	1	BPS	1750	0.168	1,693	
			24/9	26/2	embatu	1	BPS	2725	0.177	2,608	

Best yields were again obtained with Embatu; 1617 kg/ha on average. Yield of Way Rarem (1149 kg/ha) is comparable to that of local varieties (1156 kg/ha). Yield of Jatiluhur (1391 kg/ha) is slightly above that of Way Rarem. Such production levels recoup the cost of fertilization. Crop protection, sufficient weeding and suitable fertilization show that upland rice cropping can still be interesting, however, return to labour is still relatively low. An advantage is that rubber and the associated trees directly profit from good intercrop management; growth is enhanced and the immature period will be reduced.

RAS 2.2 Rice trials in the second year of planting: 1996/97

RAS 2.2 in Kopar/Engkayu in 1996/1997

Table 10 and Figure 10 show the significant effect of BPS fertilization (for Way Rarem and Embatu varieties) compared to 0 fertilization; 1277 kg/ha and 891 kg/ha respectively. When the higher CRIFC fertilization level is used, yields are highest (1325 kg/ha), but the increased costs of the inputs do not justify their use from an economic point of view. All results are presented in Figure 11.

Table 10. **Upland rice yield observed in RAS plot in the 1996/97 planting season, West Kalimantan**

	code	Yield/ha	STD		No. plots	Index/ dose 0
Average 0 fertilization	0	891	46	5%	2	
Average medium fertilization (BPS)	BPS	1,277	497	39%	3	143%
Average high fertilization : CRIFC	CRIFC	1.325	742	56%	3	149%

Figure 10.

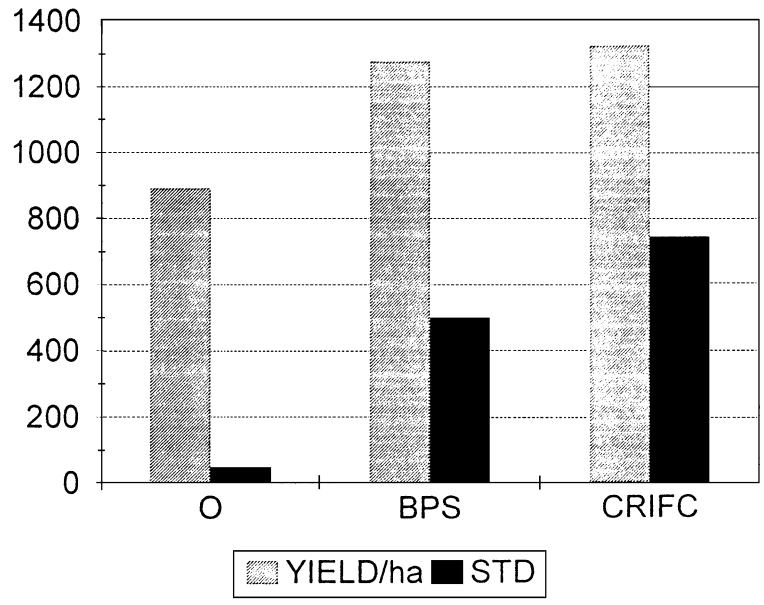
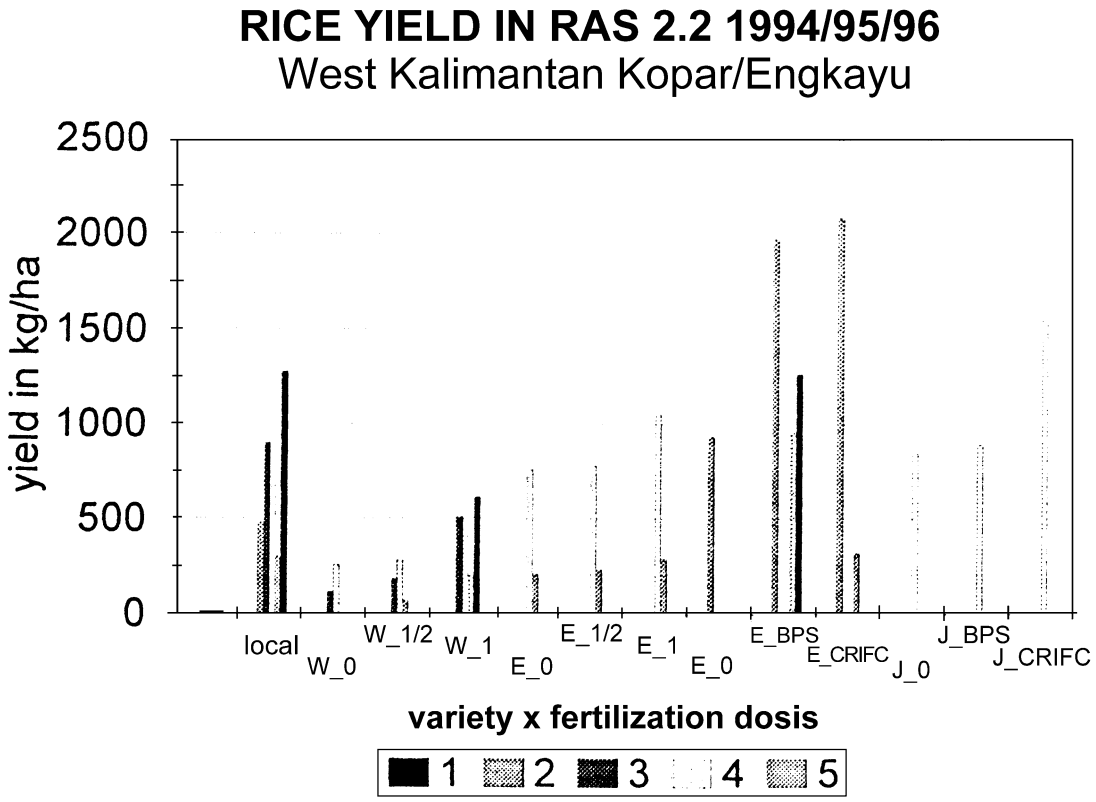


Table 11. Upland rice yield observed in RAS plot in the 3 planting seasons, West Kalimantan

RAS 2.2 planted in 1995 in Kopar/Engkayu I

Village Dusun	Farmer	Type of RAS	Rice yield 1994/95 local varieties no fertilization	Rice yield 1995/96			Rice yield 1996/97		
				Variety	Fertilizers dosis type	Yield	Variety	Fertilizers dosis type	Yield
Kopar I	Muksin	RAS 2.2	486				embatu	0	937
							embatu	BPS	1.979
							embatu	CRIFC	2.090
Engkayu I	Gabriel/2	RAS 2.2	897	Way Rarem	0	113		0	
				Way Rarem	1/2 BPS	181		BPS	
				Way Rarem	BPS	512		CRIFC	
Engkayu I	Andreas	RAS 2.2	674	Way Rarem	0	256	jatiluhur	0	845
				Way Rarem	1/2 BPS	283	jatiluhur	BPS	891
				Way Rarem	BPS	419	jatiluhur	CRIFC	1.563
				embatu	0	760			
				embatu	1/2 BPS	780			
				embatu	BPS	1055			
Engkayu I	Gamin	RAS 2.2	299	Way Rarem	0	0		0	0
				Way Rarem	1/2 BPS	69	embatu	BPS	961
				Way Rarem	BPS	207	embatu	CRIFC	320
				embatu	0	207			
				embatu	1/2 BPS	230			
				embatu	BPS	291			
Engkayu I	Gabriel/1	RAS/3 clones control	1274	Local		615	semamu	BPS	1.266

Figure 11.



RAS 2.2 in Pariban Baru in 1996/97

In Sintang/Pariban Baru, in the third year after rubber planting, almost all RAS 2.2 rice trials failed, regardless of fertilization levels or rice varieties. This was due to the following factors:

- shade from rubber trees (the 3.5 year old PB 260 trees had a very well developed canopy in February 1997 at the time of the rice harvest),
- excessive soil compaction (as there was no tillage since rubber was planted), and this limited root development,
- inefficiency of fertilization due to soil compaction,
- insect attacks (walang sangit).

The few results are shown in Figure 12. Yields are still very low, 200 - 250 kg/ha with BPS fertilization and up to 450 kg/ha with CRIFC fertilization. Table 13 and Figure 13 show the yield evolution over three years for three fields. A constant decrease in yield, even with fertilization is seen. Generally yields are very low, and do not justify the fertilization, or even the labour costs.

Table 12. Upland rice yield observed in RAS Plot in the 1996/97 planting season, West Kalimantan

Village Dusun	Farmer	Type of RAS RAS 2.2	Rice planting in 96/97 Planting	Harvesting	Variety		Fertilizers dosis type	Number of weedings	Gross Yield	% dry	Net yield	Intercropped
		Associated Trees Medium Density										
Pariban baru	Sudin	2.2/REP1							0			
Pariban baru	Haruk	2.2/REP2							0			
Pariban baru	Sadang	2.2/REP3	7/10	21/1	Jatiluhur	4	0		128	0.22	116	
			1/10	21/1	Jatiluhur	4	BPS		215	0.209	198	
Pariban baru	Anat	2.2/REP4	6/10	21/1	Jatiluhur	4	BPS		275	0.237	244	
			9/10	21/1	Jatiluhur	4	CRIFC		575	0.303	466	
Pariban baru	Amas	2.2/REP5							0			
		Associated Trees High Density										
Pariban baru	Apin	2.2/REP1							0			
Pariban baru	Hukir	2.2/REP2							0			
Pariban baru	Sang-gang	2.2/REP3	10/10	21/1	Way Rarem	4	0		200	0.284	167	
Pariban baru	Atat	2.2/REP4							0			

Figure 12.

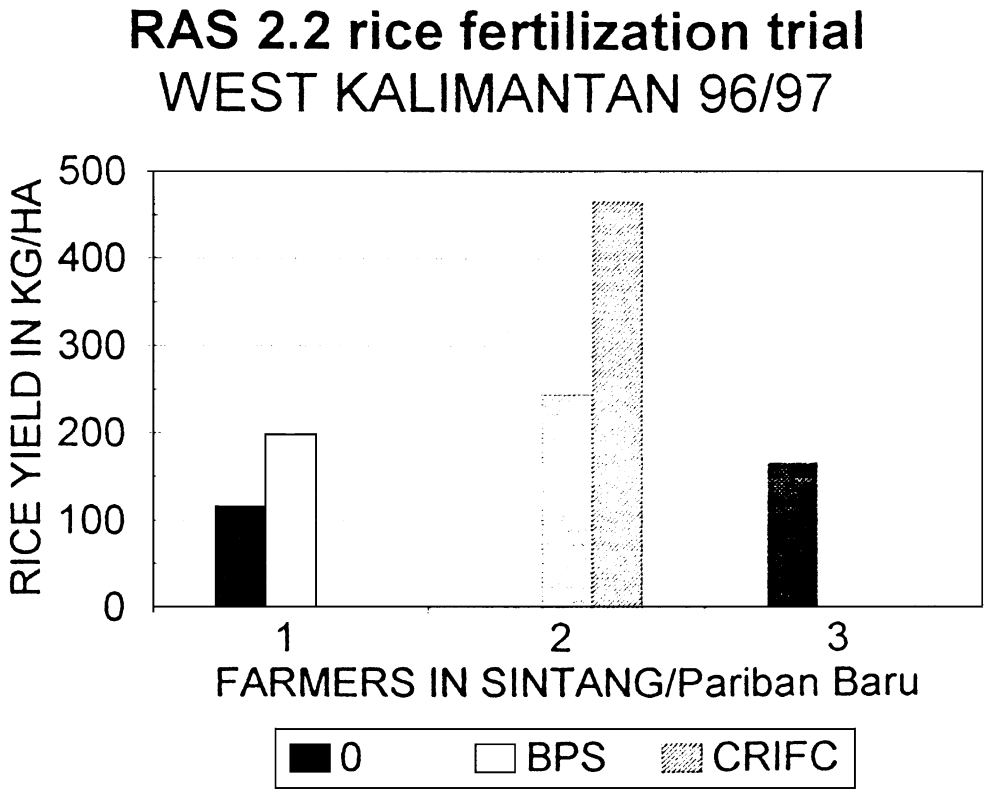

RAS 2.2 rice fertilization trial
WEST KALIMANTAN 96/97
RICE YIELD IN KG/HA
500
400
300
200
100
0
1
2
3
FARMERS IN SINTANG/Pariban Baru
0
BPS
CRIFC

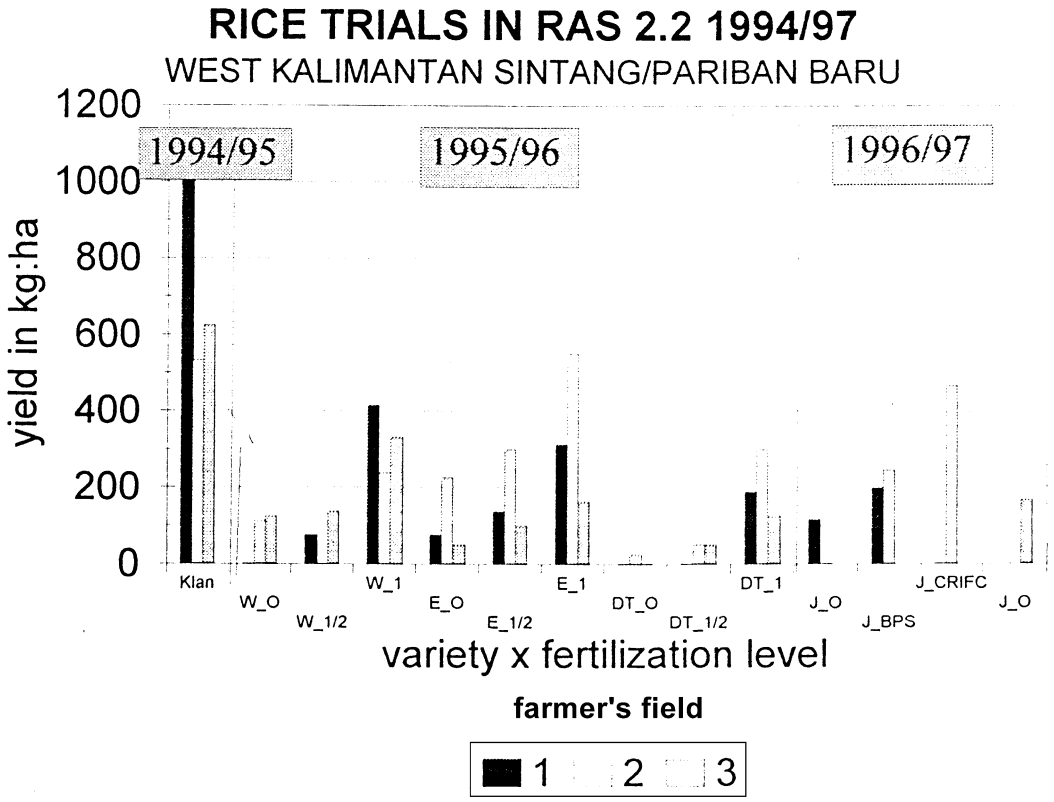
Table 13. Upland rice yield observed in RAS plot in the 3 planting seasons, West Kalimantan

RAS 2.2 planted in 1993 in Sintang/Pariban Baru

Farmer	Type of RAS	Code farmer	Rice yield 1994/95 local varieties no fertilization Klan	Rice yield 1995/96								
				Way Rarem dose 0	Way Rarem dose 1/2	Way Rarem BPS	embatu dose 0	embatu dose 1/2	embatu BPS	Danau tempe dose 0	Danau tempe dose 1/2	Danau tempe BPS
				W 0	W 1/2	W 1	E 0	E 1/2	E 1	DT 0	D	DT I
Sadang	RAS .2	1	1029	0	75	416	75	138	3131	0	0	188
Anat	RAS 2.2	2	533	113		238	225	3001	550	25,	501	300
Sanggang	RAS 2.2	3	625	125		333	501 klanggau	100 klanggau	1631 klanggau	01	501	125

Farmer	Type of RAS	Code farmer	Rice yield 1994/95 local varieties no fertilization Klan	Rice yield Jatiluhur dose 0	1996/97 Jatiluhur BPS	Jatiluhur CRIFC	Way Rarem dose 0
				J 0	J BPS	J CRIFC	J 0
Sadang	RAS 2.2	1	1029	116	198	0	
Anat	RAS 2.2	2	533	0	244	466	
Sanggang	RAS 2.2	3	625				

Figure 13.



Results from Pariban Baru suggest that even with good management and high input use, intercropping with rice, with no tillage is still very risky. This is due to the very poor soils, and the fact that plots were derived from land covered with *Imperata*. Comparison with results from Embaong and Kopar in 1996/97 also suggests that when rice can profit from good soil structure and high nutrient stocks from the burning of a large biomass, yields may reach 1000 to 1500 kg/ha.

RAS 2.2 in Trimulia in 1996/97

When the rice trials were a total failure in 1995/96, farmers learned from that experience and tried to obtain a reasonable production in 1996/97. Plots with no fertilization all failed, as did those with CRIFC fertilization, although this was due to poor management and *Imperata* infestation. Only plots with BPS fertilization gave satisfactory yields ranging from 233 to 1446 kg/ha (average yield 684 kg/ha).

Table 14. **Upland rice yield observed in RAS plot in the 1996/97 planting season, West Kalimantan**

Transmigration area: Trimulia

Second year of cropping

Farmer	Type of RAS	Fertilizers dosis type	Net Yield
Pryo Aryono	2.1	BPS	465
Poniman	2.1	BPS	233
Yasdi	2.1	BPS	358
Sodianto	2.1	BPS	0
Rapi Aryo	2.2/annual	0	0
		BPS	961
		CRIFC	0
Suwito	2.2/annual	BPS	1,446
		BPS	639
		CRIFC	1,838
Average B		AVG/BPS	684
STD			412
CV			60.23%

The same observations as the previous year can be made; most farmers prioritized sawah, and in these former *Imperata* savannah fields with degraded and depleted soils, rice cropping is very risky, a situation similar to that of Pariban Baru. In this type of situation, rice yields above 500 kg/ha remain exceptional.

Conclusion

Too many crops failed to give satisfactory results in the transmigration areas which were formerly *Imperata* savannah. It shows that in actual farmers' conditions, it may be hazardous to build a strategy based on intensive upland rice intercropping. There is probably a better scope for groundnut, although this requires more labour (tillage).

On the other hand, recent experimentation in 1996/97, particularly in Embaong, shows that rice cropping can be profitable in certain conditions. These include the use of adapted varieties, including local ones (Embatu), good fertilization, weeding and crop protection in fields which have a good soil structure, for example those derived from old jungle rubber.